

## Radio Science and Astronomy Missions: Giant Planet Orbiters

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We propose a series of small, low-cost Radio Science and Astronomy Mission (RSAM) orbiters suitable for intense study of the giant planets. These missions will provide fundamental new information on the atmospheres, interiors, rings, and satellites of Jupiter, Saturn, Uranus, and Neptune, using a combination of space-proven occultation, bistatic radar, celestial mechanics and radiometry methods. The instrument is a high precision tri-frequency (S, X, and Ka bands) radio system and powerful digital signal processor. Orbital tours last one year, with orbital periods about one month, varying by planet. Frepulsive inclination "cranking" aided by satellite gravity assists, achieves global coverage.

RSAM's highly flexible instrument addresses a wide range of science objectives. Studies of zonal wind dynamics, their effects on planetary figure and variation with altitude, use repeated dual-frequency uplink radio occultations, tri-frequency radiometry, and precision two-way Ka-band Doppler tracking. Occultations also provide vertical ionospheric structure profiles at equatorial to auroral latitudes and, combined with radiometry, provide vertical thermal profiles (that yield atmospheric stability parameters) from .01 mbar to several bars. Doppler tracking maps gravity fields, providing information on large-scale atmospheric and interior structures. Occultation measurements of ring structure, particle size distribution, shape, and thickness are used to infer ring dynamics and gravitational interactions within a planetary system. For satellites, a combination of uplink occultations, bistatic radar, and Doppler tracking will yield mass, density, surface properties, and atmospheric structure.

A typical RSAM mission uses a low-periapsis orbit whose period allows time for precision observations near periapsis and near satellites, telemetry of observation data to Earth, and preparation for subsequent observations. As its inclination is cranked from equatorial to polar (polar to equatorial for Uranus), it should provide near-vertical Earth occultations at all latitudes. The minimum flight time option uses a Delta launch vehicle, with one Earth gravity assist, to reach Jupiter in 4.7 years, although direct trajectories with shorter flight times are being studied.

RSAM is a 110 Kg spin-stabilized spacecraft carrying up to 130 Kg of bipropellant for maneuvering, orbit insertion, and cranking. Power is provided by a 63-watt RTG. A 5-watt Ka-band amplifier feeding a 1.5 meter HGA provides telemetry. The science instruments consist of an X-band radiometer and highly sensitive S and Ka band receivers, referenced to an ultra-stable oscillator. Observation data are compressed by a digital signal processor and stored in a 100 Mbit solid state memory for subsequent playback to Earth at 3 Kbps. High power DSN transmitters at S and Ka bands provide precision carriers for the uplink experiments. Critical spacecraft subsystems are redundant anti can be cross-strapped for additional reliability.

RSAM is designed to be consistent with Discovery Program cost and schedule guidelines. The spacecraft development period is 3 years; the development cost, including contingency, is \$139 million.